Mon. Not. R. Astron. Soc. **000**, 1–?? (2005) Printed 5 February 2008 (MN LATEX style file v2.2)

RR Lyrae-based calibration of the Globular Cluster Luminosity Function

M. Di Criscienzo[1 2⋆], F. Caputo[3⋆], M. Marconi[1⋆], I. Musella[1⋆]

[1] *INAF-OAC,Via Moiarello 16, I-80131, Naples, Italy*

[2] *Universitá "Tor Vergata", via della Ricerca Scientifica, 1, Rome, Italy*

[3] *INAF-OAR, Via di Frascati 33, I-00040, Monte Porzio Catone, Italy*

Accepted ???. Received ???; in original form ???

ABSTRACT

We test whether the peak absolute magnitude $M_V(TO)$ of the Globular Cluster Luminosity Function (GCLF) can be used for reliable extragalactic distance determinations. Starting with the luminosity function of the Galactic Globular Clusters listed in Harris catalog, we determine $M_V(TO)$ either using current calibrations of the absolute magnitude $M_V(RR)$ of RR Lyrae stars as a function of the cluster metal content [Fe/H] and adopting selected cluster samples. We show that the peak magnitude is slightly affected by the adopted $M_V(RR)$-[Fe/H] relation, with the exception of that based on the revised Baade-Wesselink method, while it depends on the criteria to select the cluster sample. Moreover, grouping the Galactic Globular Clusters by metallicity, we find that the metal-poor ([Fe/H] < -1.0, $\langle$[Fe/H]$\rangle \sim -1.6$) sample shows peak magnitudes systematically brighter by about 0.36 mag than those of the metal-rich ([Fe/H] > -1.0, ($\langle$[Fe/H]$\rangle \sim -0.6$) one, in substantial agreement with the theoretical metallicity effect suggested by synthetic Globular Cluster populations with constant age and mass-function. Moving outside the Milky Way, we show that the peak magnitude of the metal-poor clusters in M31 appears to be consistent with that of Galactic clusters with similar metallicity, once the same $M_V(RR)$-[Fe/H] relation is used for distance determinations. As for the GCLFs in other external galaxies, using Surface Brightness Fluctuations (SBF) measurements we give evidence that the luminosity functions of the blue (metal-poor) Globular Clusters peak at the same luminosity within ~ 0.2 mag, whereas for the red (metal-rich) samples the agreement is within ~ 0.5 mag even accounting for the theoretical metallicity correction expected for clusters with similar ages and mass distributions. Then, using the SBF absolute magnitudes provided by a Cepheid distance scale calibrated on a fiducial distance to LMC, we show that the $M_V(TO)$ value of the metal-poor clusters in external galaxies is in excellent agreement with the value of both Galactic and M31 ones, *as inferred by a RR Lyrae distance scale referenced to the same LMC fiducial distance*. Eventually, adopting μ_0(LMC)=18.50 mag, we derive that the luminosity function of metal-poor clusters in the Milky Way, M31, and external galaxies peak at $M_V(TO)=-7.66\pm0.11$ mag, -7.65 ± 0.19 mag and -7.67 ± 0.23 mag, respectively. This would suggest a value of -7.66 ± 0.09 mag (weighted mean), with any modification of the LMC distance modulus producing a similar variation of the GCLF peak luminosity.

Key words: Stars, variable; clusters, globular.

1 INTRODUCTION

In several fields of modern astronomy, the determination of extragalactic distances is based on a ladder which is firmly anchored to Classical Cepheids and RR Lyrae stars, the "primary" standard candles for Pop. I and Pop. II stellar systems, respectively, with the properties of these variables used to calibrate "secondary" indicators which step-by-step lead us through the Local Group up to cosmologically significant distances.

In this context, the Globular Cluster Luminosity Function (GCLF) is playing an ever increasing role to estimate the distance to galaxies within ~ 30 Mpc, as witnessed by

⋆ E-mail: dicrisci@na.astro.it (MDC); caputo@mporzio.astro.it (FC); marcella@na.astro.it (MM); ilaria@na.astro.it (IM)

Table 1. Globular Clusters in the Milky Way. Columns (1)-(4) are taken from Harris (1996, 2003 update). while columns (5)-(8) give the cluster absolute integrated magnitude according to the $M_V(RR)$-[Fe/H] relations discussed in the text (see also Fig.2). Clusters marked (a) and (b) are suspected to belong to the Sculptor and the Canis Major dwarf galaxy respectively, while Pal 1, N2419 and N5139 (ω Cen) might be associated with now not extant dwarf galaxies (this table is available entirely in the electronic form).

Name (1)	[Fe/H] (2)	$M_V(GC)$ (3:H96)	R_{GC} (4:H96)	$M_V(GC)$ (5:S93)	$M_VGC)$ (6:F98)	$M_V(GC)$ (7:G03)	$M_V(GC)$ (8:B03)
N104	−0.76	−9.42	7.4	−9.40	−9.28	−9.39	−9.36
N288	−1.24	−6.74	12.0	−6.78	−6.62	−6.73	−6.76
N362	−1.16	−8.41	9.4	−8.45	−8.29	−8.41	−8.42
N1261	−1.35	−7.81	18.2	−7.87	−7.70	−7.82	−7.85
Pal 1	−0.60	−2.47	17.0	−2.42	−2.32	−2.42	−2.37
AM 1	−1.80	−4.71	123.2	−4.84	−4.62	−4.75	−4.81

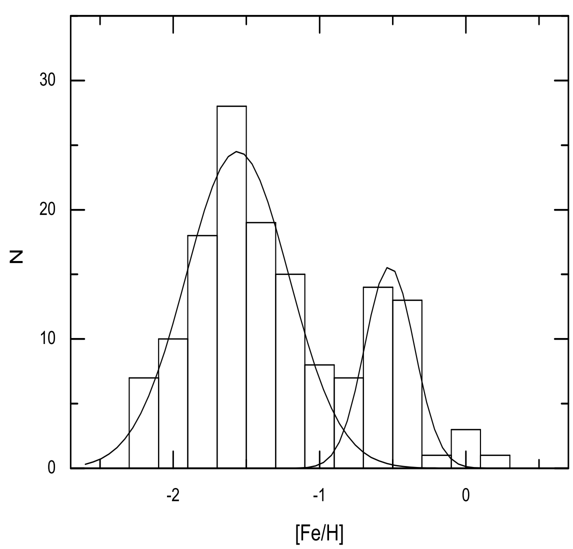

Figure 1. Frequency distribution of metallicity for GCs in the Milky Way. The data have been fitted with the two Gaussian curves shown in the figure.

the huge amount of relevant papers published in the last decade. In the past, its use was hampered by the lack of observations of Globular Clusters (GC) beyond the Local Group but with the advent of modern telescopes, above all the Hubble Space Telescope (HST), it is now possible to resolve stellar populations in faraway galaxies, identify the GC candidates, measure their integrated magnitude and finally build the related luminosity function.

The GCLF method is based on the assumption that within each galaxy hosting statistically significant numbers of GCs, the frequency of the cluster integrated magnitude $V(GC)$ exhibits a universal shape which can be fitted with a Gaussian distribution

$$\frac{dN}{dV} = Ae^{-\frac{[V(GC)-V(TO)]^2}{2\sigma^2}}$$

where dN is the number of clusters in the magnitude bin dV, $V(TO)$ is the magnitude of the peak or turnover, σ is the Gaussian dispersion and A the normalization factor. Once the turnover absolute value $M_V(TO)$ is known to be constant or varying in a predictable way, the distance to the parent galaxy follows immediately from the apparent (reddening corrected) magnitude of the GCLF peak. This relation is not universally accepted (see, e.g., Richtler 2003 and references therein) and several authors prefer to use a t-distribution (see Secker 1992, Secker & Harris 1993, Barmby, Huchra & Brodie 2001, hereafter BHB), but with unimportant differences with the Gaussian turnover magnitude (Della Valle et al. 1998, BHB). Moreover, it should be noted that also the use of the GCLF for trustworthy distance determinations is argued because the absolute peak magnitudes suggested so far by the various authors show a scatter of about 0.5 mag (see Ferrarese et al. 2000). In any case, the only galaxy where Globular Clusters can be observed well over the turnover, down to the faintest integrated magnitudes, and where the cluster individual distances are determined with a sufficiently high level of confidence, as inferred from the observed magnitude of the horizontal branch (HB) or the RR Lyrae stars, is the Milky Way. For these reasons, the absolute LF of Galactic Globular Clusters (GGCs) represents the first (obligatory) step to the calibration of extragalactic luminosity functions. Unfortunately, for the Milky Way itself current $M_V(TO)$ values show a large scatter, from ~ -7.3 mag (Secker 1992) to ~ -7.6 mag (Sandage & Tammann 1995), thus implying unpleasant uncertainties on the determination of the distance to external galaxies. In order to investigate the source of such a discrepancy, in the first part of Section 2 we estimate the effects on the Milky Way GCLF as due to the adopted metallicity calibration of the RR Lyrae absolute magnitude and to selective criteria of the GC sample, while Section 3 deals with GCs in M31. As for other external galaxies where no RR Lyrae stars are observed, in Section 4 we compare the apparent magnitude of the GCLF turnover with the Surface Brightness Fluctuations measurements. In this way, we also check the consistency between GCLF distances, which are based on the RR Lyrae luminosity scale, and those provided by the latter method, which is calibrated on Cepheid distances. The conclusions close the paper.

Table 2. RR Lyrae-based intrinsic distance moduli μ_0(mag) of LMC and M31. The errors in parenthesis take into account the uncertainty on [Fe/H].

Ref.	$V_0(RR)$	[Fe/H]	μ_0(H96)	μ_0(S93)	μ_0(F98)	μ_0(G03)	μ_0(B03)
LMC							
Wa92	18.95(0.04)	−1.9	18.44(0.05)	18.58(0.07)	18.35(0.09)	18.48(0.09)	18.55(0.06)
Cl03	19.06(0.06)	−1.5	18.49(0.08)	18.57(0.11)	18.38(0.09)	18.50(0.09)	18.55(0.11)
Da04		−1.7					18.52(0.12)
Bo04		−1.5					18.48(0.08)
mean			18.47±0.08	18.58±0.11	18.37±0.11	18.49±0.13	18.53±0.11
M31							
Br04	25.03(0.01)	−1.6	24.47(0.05)	24.57(0.09)	24.37(0.06)	24.49(0.07)	24.55(0.08)
Br04	25.06(0.01)	−1.3	24.46(0.05)	24.51(0.09)	24.34(0.06)	24.46(0.07)	24.49(0.08)
mean			24.47±0.07	24.54±0.11	24.36±0.08	24.48±0.08	24.52±0.10

Ref. Wa92: Walker (1992, Globular Clusters); Cl03: Clementini et al. (2003, Field); Da04: Dall' Ora et al. (2004, Globular Cluster, K magnitudes); Bo04: Borissova et al. (2004, Field, K magnitudes); Br04: Brown et al. (2004, Field. The two measures refer to *ab* and *c*-type variables. The original [Fe/H] values are increased by 0.1 dex to put the Zinn & West (1995) scale in agreement with the H96 scale.)

2 THE MILKY WAY ABSOLUTE GCLF

Almost all the recent papers dealing with the LF of Galactic Globular Clusters adopt the data collected by Harris (1996). Using this catalog (2003 update, hereafter H96), and leaving out those for which all the required information are not available, we list in Table 1 the 144 clusters with measured metal content [Fe/H], apparent magnitude of the horizontal branch $V(HB)$ and apparent integrated magnitude $V(GC)$. In this Table, we have excluded AM4 whose available photometry (Inman & Carney 1987) shows no stars brighter than the main-sequence turnoff. Moreover, following recent suggestions (see van den Bergh 2003, van den Bergh & Mackey 2004 and references therein), we mark the clusters suspected to be not true members of the Galaxy but of the Sculptor dwarf galaxy [N6715(M54), Ter 7, Ter 8, Arp 2, Pal 12, N4147, and Pal 2] or of the Canis Major dwarf galaxy [N1851, N1904, N2298, and N2808]. Let us also note that the same authors suggest that Pal 1, N5139(ω Cen), and N2419 might have formed in now disrupted dwarf galaxies.

The global features of the GGCs have been extensively studied (see, e.g., van den Bergh & Mackey 2004, van den Bergh 2003 and references therein) and here we wish only to draw attention to the cluster metallicity dichotomy at [Fe/H] ~ -1.0, with the metal-poor component containing about 3/4 of all clusters. Based on the H96 metal contents, we show in Fig. 1 that the total distribution can well be described by two Gaussian curves peaked at [Fe/H] $\sim -1.55\pm0.04$ (σ=0.35±0.08) and -0.55 ± 0.06 (σ=0.38±0.09). As a whole, no metal-rich cluster is observed at Galactocentric distances $R_{GC} > 8$ kpc, except the suspected peculiar (see above) clusters Pal 1, Pal 12, and Ter 7, while those located within 8 kpc span a metallicity range from [Fe/H]~ -2.3 to ~ 0. As for the absolute integrated magnitude $M_V(GC)$ and R_{GC} distance listed in the Harris' catalog [columns (3) and (4) in Table 1], they rest on the cluster distance modulus determined by adopting $V(HB)$=$V(RR)$ and the H96 relation:

$$M_V(RR) = 0.80 + 0.15[Fe/H] \quad (2)$$

which provides a rather smooth luminosity decrease from metal-poor to metal-rich clusters. However, the recent review by Cacciari & Clementini (2003) shows that a general consensus on the $M_V(RR)$-[Fe/H] calibration of RR Lyrae stars has not been achieved yet, with the longstanding debate concerning both the zero point and the slope of the calibration. Since the $M_V(GC)$ values depend on the cluster distance modulus, i.e. on the adopted $M_V(RR)$-[Fe/H] relation, we show in Fig. 2 the comparison between equation (2) and some relevant results presented in the recent literature. Specifically, we use the typical "long-scale" calibration by Sandage (1993, S93)

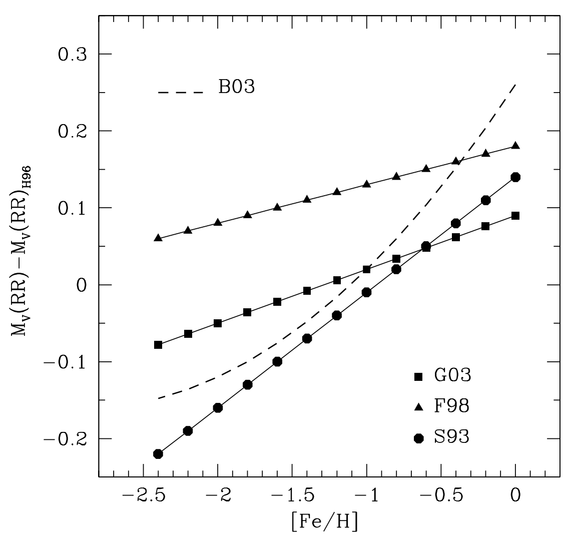

Figure 2. Comparison between the $M_V(RR)$-[Fe/H] relations discussed in the text.

$$M_V(RR) = 0.94 + 0.30[Fe/H], \quad (3)$$

the revised Baade-Wesselink ("short-scale") one by Fernley

et al. (1998, F98)

$$M_V(RR) = 0.98 + 0.20[Fe/H], \qquad (4)$$

and the relation inferred by Gratton et al. (2003, G03)

$$M_V(HB) = 0.89 + 0.22[Fe/H] \qquad (5)$$

on the basis of the main-sequence fitting procedure. Furthermore, since several observational and theoretical studies (see Bono et al. 2003, Di Criscienzo, Marconi & Caputo 2004 and references therein) suggest that the $M_V(RR)$-[Fe/H] is not linear, becoming steeper when moving toward larger metal content, the two linear relations presented by Bono et al. (2003, B03) for GCs with [Fe/H] < -1.6 and ≥ -1.6 have been approximated in the quadratic form

$$M_V(RR) = 1.06 + 0.44[Fe/H] + 0.05[Fe/H]^2, \qquad (6)$$

as shown in the figure with a dashed line. As irony of fate, all these relations yields for the "prototype" variable RR Lyr itself ([Fe/H]=-1.39) an absolute magnitude which is consistent with the value M_V=0.61±0.12 mag determined from the HST astrometric parallax π_{HST}=3.82±0.20 mas and current uncertainty on the extinction correction (see Benedict et al. 2002), thus hindering us from any a priori selection. This also in consideration of the fact that the absolute magnitude of RR Lyrae stars is expected to depend also on the HB morphology, becoming brighter up to $\sim$ 0.1 mag, at fixed metal content, when the population of HB stars moves from red to blue (see, e.g., Demarque et al. 2000, Cassisi et al. 2004 and references therein). On this ground, we estimate that the zero-point of all the $M_V(RR)$-[Fe/H] relations has an intrinsic uncertainty of about 0.05 mag.

However, with everything else being constant, inspection of data in Fig. 2 discloses that the effects of the adopted $M_V(RR)$-[Fe/H] relation on the $M_V(GC)$ magnitude of individual clusters may amount to quite significant values. We therefore decide to use all the $M_V(GC)$ values listed in Table 1 to construct the LFs generated by the various $M_V(RR)$-[Fe/H] calibrations adopted in this paper. Before proceeding, we give in Table 2 the RR Lyrae-based intrinsic distance moduli μ_0 of the Large Magellanic Cloud (LMC) and M31, as inferred by these $M_V(RR)$-[Fe/H] relations. We also list the results provided by recent near-infrared observations of LMC RR Lyrae stars and theoretical predictions discussed in B03. According to the data in Table 2, the adopted $M_V(RR)$ calibration modifies the RR Lyrae distance to LMC and M31, but without effect on the relative distance of the two galaxies which turns out to be μ_0(M31)$-\mu_0$(LMC)=6.0±0.1 mag. Concerning the absolute distance to LMC, which is a benchmark to the Cepheid distance scale, we recall the wide range spanned by current estimates (see Caputo et al. 2000; Gibson et al. 2000, Clementini et al., 2003), including those provided by SN1987A (μ_0=18.50±0.05 mag, Panagia 1998) and eclipsing binaries (μ_0=18.23-18.53 mag, Fitzpatrick et al. 2003).

Figure 3 shows the luminosity function of our GGC full sample [hereafter H96(a)] using the absolute integrated magnitudes listed by H96(column (3) in Table 1). The data have been fitted with a two-parameters (turnover and dispersion) Gaussian curve varying the width (0.2, 0.3, 0.4 mag) and the center of the magnitude bins. The resulting averaged

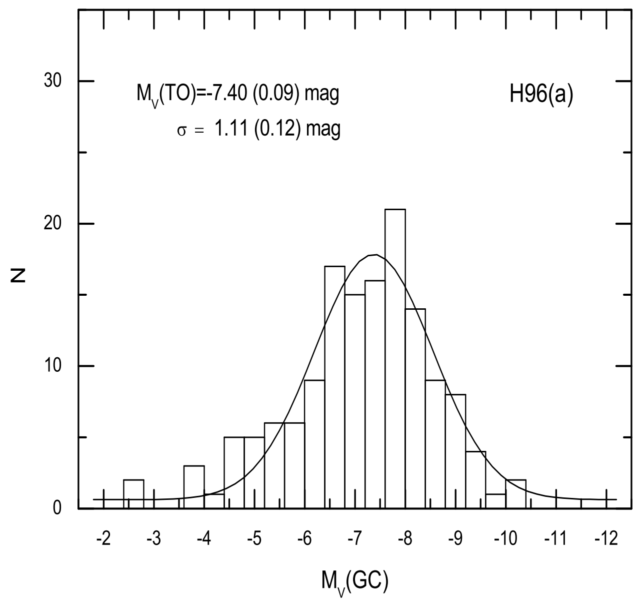

Figure 3. GCLF for Galactic clusters in our full sample H96(a).

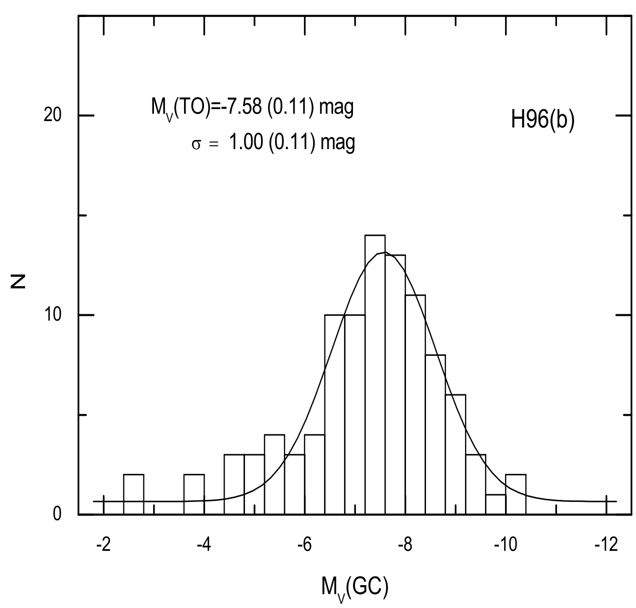

Figure 4. As in Fig. 3, but for the selected sample H96(b).

Table 3. $M_V(TO)$ and σ values of GGCs as based on the $M_V(RR)$-[Fe/H] relations discussed in the text. The results are based on the H96 catalog of GGCs with (a) denoting the full sample and (b) the Secker (1992) selection (see text).

Sample	⟨[Fe/H]⟩	$M_V(RR)$	$M_V(TO)$	σ
H96(a)	−1.29±0.57	H96	−7.40±0.09	1.11±0.12
N=144		S93	−7.46±0.11	1.14±0.13
		F98	−7.26±0.08	1.11±0.10
		G03	−7.40±0.11	1.14±0.12
		B03	−7.40±0.09	1.14±0.11
H96(b)	−1.39±0.51	H96	−7.58±0.11	1.00±0.11
N=100		S93	−7.66±0.11	1.04±0.12
		F98	−7.47±0.10	1.00±0.11
		G03	−7.62±0.11	1.02±0.12
		B03	−7.64±0.12	1.00±0.11

Table 4. As in Table 3. but for metal-rich (MR: [Fe/H]>−1.0) and metal-poor (MP: [Fe/H] <−1.0) GGCs.

H96(a)	MR: N=44 ⟨[Fe/H]⟩=−0.57±0.26	MP: N=100 ⟨[Fe/H]⟩=−1.61±0.30
$M_V(RR)$	$M_V(TO)(\sigma)$	$M_V(TO)(\sigma)$
H96	−7.20±0.18(1.08±0.23)	−7.49±0.09(1.09±0.11)
S93	−7.17±0.19(1.08±0.23)	−7.56±0.10(1.12±0.12)
F98	−7.04±0.14(1.09±0.19)	−7.35±0.08(1.10±0.10)
G03	−7.18±0.20(1.07±0.25)	−7.50±0.09(1.10±0.10)
B03	−7.08±0.19(0.99±0.23)	−7.55±0.09(1.12±0.12)
H96(b)	MR: N=26 ⟨[Fe/H]⟩=−0.67±0.21	MP: N=74 ⟨[Fe/H]⟩=−1.64±0.31
$M_V(RR)$		$M_V(TO)(\sigma)$
H96	∼ −7.4	−7.63±0.09(1.00±0.10)
S93	∼ −7.3	−7.72±0.10(1.02±0.12)
F98	∼ −7.2	−7.52±0.12(1.00±0.11)
G03	∼ −7.3	−7.65±0.11(1.00±0.12)
B03	∼ −7.3	−7.70±0.11(1.00±0.11)

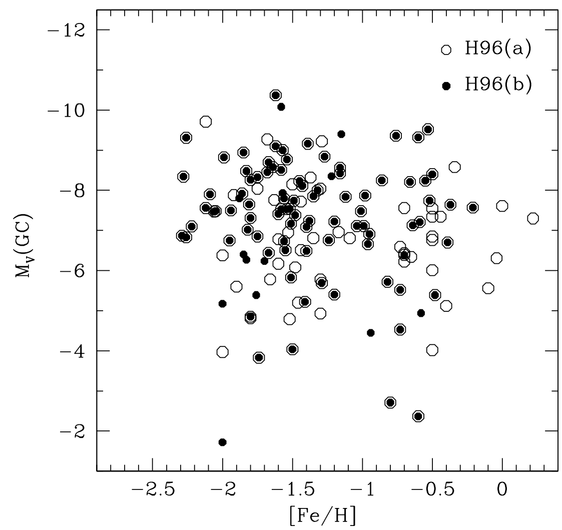

Figure 5. Absolute integrated magnitudes versus Galactocentric distances for Galactic Globular Clusters in the full [H96(a)] and the selected [H96(b)] samples.

values of $M_V(TO)$ and σ are reported in the figure. This procedure should allow us to take into account the intrinsic dispersion of the $M_V(RR)$-[Fe/H] relation as well as the additional effects due to the uncertainty of the apparent integrated visual magnitude $V(GC)$ and the adopted metallicity scale. We remind that accurate integrated photometry of Galactic GCs is difficult, especially for those located in crowded regions toward the Galactic Center, at large distances or with low luminosity. However, most of the $V(GC)$ values reported in the Harris catalog, as obtained from consistent original databases and based on concentric-aperture photometry of the clusters, are accurate till ∼ 0.1 mag and only for a small number of sparse and/or faint clusters the accuracy is worse than 0.1 mag. On the other side, the scale from Zinn & West (1984) used by H96 and the one from Carretta & Gratton (1997) adopted by G03 show a maximum discrepancy of ∼ 0.2 dex at intermediate metal deficiency (−1.0≤ [Fe/H] ≤ −1.9, see Kraft & Ivans, 2003), thus introducing a maximum uncertainty of the order of 0.03 mag on $M_V(RR)$.

The resulting peak magnitude$M_V(TO)$=−7.40±0.09 mag is fully consistent with−7.44±0.15 mag and −7.40±0.11 mag, as obtained by Kavelaars & Hanes (1997) and Harris (2001), respectively, on the basis of H96 catalog and $M_V(RR)$calibration. We therefore repeat the procedure adopting the$M_V(GC)$ values given in columns (5)-(8) of Table 1, with the numerical results labelled H96(a) in the first part of Table 3. Quite surprisingly, we derive that, in spite of the different zero points and slopes, the adopted dependence of $M_V(RR)$ on metallicity does not modify significantly the peak magnitude, with the exception of the F98 relation which gives a value fainter by ∼ 0.15 mag with respect to the average $M_V(TO)$=−7.42±0.11 mag of the other calibrations. In this, our turnover magnitude $M_V(TO)$=−7.26±0.08 mag based on the F98 calibration agrees with−7.29±0.13 mag, as determined by Secker (1992) using a previous GC catalog (Harris et al. 1991) and $M_V(RR)$=1.00+0.20[Fe/H], which is only 0.02 mag fainter than equation (4).

However, at variance with the above agreement with the quoted studies, our results are fainter than $M_V(TO)$=−7.60±0.11 mag, the peak magnitude obtained by Sandage & Tammann (1995) with the S93 relation, and than −7.55±0.14 mag, as determined by Larsen et al. (2001, hereafter L01) from the H96 absolute integrated magnitudes. We note that those two results deal with the selected GGC subset as earlier adopted in the Secker (1992) study, namely hold for GCs with $E(B\text{-}V)$ ≤1.0 mag and 2 ≤ R_{GC} ≤35 kpc. For this reason, we repeat our analysis by applying this selection to all the clusters in Table 1. We derive, see Fig.4 and the H96(b) values listed in the second part of Table 3, that the peak magnitudes are now brighter by ∼ 0.2 mag with respect to those of our full sample H96(a). As

shown in Fig.5, where the two GC samples are plotted in the $M_V(GC)$-logR_{GC} plane, the reason of such a variation is due to the fact that Secker's selection removes a larger number of clusters fainter than −7.40 mag (the peak magnitude of the H96(a) sample, see dashed line) with respect to the brighter ones, leading to the systematic increase of the peak luminosity. Consequently, our H96(b) magnitudes $M_V(TO)$=−7.66±0.11 mag and −7.58±0.11 mag, as based on equations (3) and (2), are now in agreement with the Sandage & Tammann (1995) and L01 results, respectively, but the value based on equation (4), increased by 0.02 mag to account for the small difference with the relation adopted by Secker (1992), turns out to be significantly brighter (∼ 0.16 mag) than the Secker's value. Of importance for the following discussion is the evidence that the constraints to select the GC sample have an effect on the peak magnitude which may be larger than that introduced by the adopted RR Lyrae distance scale. This is a crucial point in view of the comparison of the Milky Way GCLF with one in another galaxy. In particular, the fact that many external galaxies show a bimodal metallicity distribution, as inferred from the color behavior, and that several studies present extragalactic GCLFs selected by the cluster metallicity or distance from the galaxy center, lead us to analyze the dependence of the Galactic GCLF on both [Fe/H] and R_{GC}.

According to Fig. 1, we split at [Fe/H]=−1.0 the GC full sample and we give in the first part of Table 4 the resulting peak magnitudes and σ values for the metal-poor (MP) and the metal-rich (MR) groups (see Fig. 6 which deals with absolute integrated magnitudes based on the H96 relation). As a whole, the peak magnitude of the MP clusters (⟨[Fe/H]⟩=−1.61) is brighter by about 0.10 mag than that of the combined sample (⟨[Fe/H]⟩=−1.29) listed in the first part of Table 3, independently of the adopted $M_V(RR)$ calibration. Moreover, even though the number of MR clusters is slightly smaller than that required to measure the Gaussian parameters with reasonable precision (N≥ 50, according to BHB), the TO magnitude of the metal-rich (⟨[Fe/H]⟩=−0.57) sample is fainter by about 0.36 mag than the value of the metal-poor one, again independently of the adopted $M_V(RR)$ calibration. As for the Secker's selection (i.e., H96(b) sample), we derive quite similar results, with the peak magnitude of MP clusters (⟨[Fe/H]⟩=−1.64) brighter by about 0.34 mag and 0.05 mag than that of the few MR ones (⟨[Fe/H]⟩=−0.67) and the combined sample (⟨[Fe/H]⟩=−1.39), respectively. It is worth noticing that such an empirical evidence is consistent, also on a quantitative way, with the theoretical calculations by Ashman, Conti & Zepf (1995, hereafter ACZ) who suggest a metallicity effect $\Delta M_V(TO)$=0.32Δ[Fe/H], as inferred by synthetic cluster populations with different metallicity and constant age and mass function.

Furthermore, the above results are in agreement with previous observations by Whitmore et al. (1995: M87), Kundu & Whitmore (1998: NGC3115), and Puzia et al. (1999: NGC 4472[1]) who find a difference between the LFs of blue (metal-poor) and red (metal-rich) GCs in a given

[1] For this galaxy, Lee, Kim & Geisler (1998) and Lee & Kim (2000) find little, if any, difference in the peak luminosities of blue and red clusters.

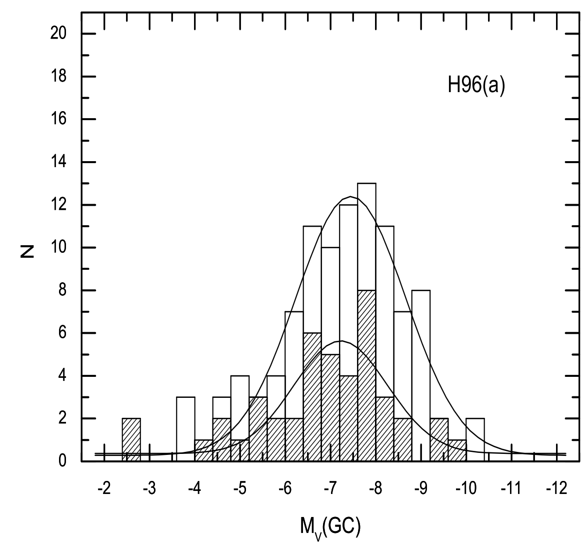

Figure 6. GCLFs for metal-poor (white area) and metal-rich (dashed area) Galactic clusters in the full sample H96(a).

galaxy in the sense that the peak visual magnitude of the former clusters is ∼ 0.13, ∼ 0.16, and ∼ 0.51 mag, respectively, brighter than that of the red ones. Moreover, L01 in their study of relatively nearby early-type galaxies which exhibit a clear dichotomy between blue and red GCs show that, fitting the luminosity functions of the two populations separately, the V-band turnover of the blue GCs is brighter by about 0.55 mag and 0.26 mag than that of the red ones and of the combined samples, respectively (see the data listed in the following Table 6). In summary, also GCs in external galaxies showing well distinct red and blue GC populations suggest that the peak magnitude becomes fainter with increasing the metal content of the GC sample, apparently following the ACZ theoretical metallicity effect. We will come back on this issue in the following section.

Concerning the dependence of $M_V(TO)$ on the cluster distance from the Galactic center, a subdivision of metal-poor clusters into inner halo ($R_{GC} \leq$ 8 kpc) and outer halo (R_{GC} >8 kpc) discloses that the shape of the GCLF varies (it is broader for the outer halo), but with no significant variation on the peak luminosity with respect to the value of the combined sample. In this, our result agrees with that obtained by Kavelaars & Hanes (1997) who use an older version of Harris catalog. For the sake of the following discussion, we have also adopted a dividing line at 3.8 kpc for the metal-poor sample, but again without finding significant variation between the peak magnitude of innermost and outermost clusters.

3 GLOBULAR CLUSTERS IN M31

In the field of distance determinations, the Andromeda galaxy plays a role of great importance because it contains either Classical Cepheids and RR Lyrae stars which provide

Table 5. $M_V(TO)$ for metal-poor ([Fe/H]=−1.57) GCs in M31.

$M_V(RR)$ (1)	$\mu_0(RR)$ (2)	$M_V(TO)$ (3)	$M_V(TO)_Z$ (4)	$M_V(TO)_Z$ (5)
H96	24.47	−7.63±0.17	−7.54	−7.57
S93	24.54	−7.70±0.19	−7.61	−7.64
F98	24.36	−7.52±0.18	−7.43	−7.46
G03	24.48	−7.64±0.18	−7.55	−7.58
B03	24.52	−7.68±0.19	−7.59	−7.62

(1): $M_V(RR)$-[Fe/H] relations discussed in Section 2; (2): RR Lyrae-based intrinsic distance moduli from Table 2; (3) $M_V(TO)$ without metallicity correction; (4) metallicity corrected $M_V(TO)$ for Δ[Fe/H] ~ -0.3 dex with respect to the average metallicity of the H96(a) sample of GCs in the Milky Way. Errors as in column (3); (5) as in column (4), but for Δ[Fe/H] ~ -0.2 dex with respect to the average metallicity of the H96(b) sample.

independent distances and consequently a valuable test for consistency between these primary distance scales. We have shown in Table 2 that the RR Lyrae-based distance to M31 depends on the adopted $M_V(RR)$-[Fe/H] calibration but, for each given relation, the relative distance with respect to LMC is constant, i.e., μ_0(M31)$-\mu_0$(LMC)= 6.0±0.1 mag. It follows that the M31 Cepheid distance μ_0=24.44±0.1 mag (Freedman & Madore 1990) calibrated on μ_0(LMC)=18.50 mag agrees with the RR Lyrae-based value, thus providing a first evidence about the internal consistency of the two distance scales. As for the GCLF method, the published values of $M_V(TO)$ span a rather discomforting range, as reported by BHB in the their recent analysis of M31 GCs. According to these authors, who study several subsamples of the cluster population, for the halo and disk clusters the peak magnitude is $V_0(TO)$=16.84±0.11 mag and 16.67±0.16 mag, respectively, while splitting the full sample at the metallicity [Fe/H]=−1.0 the metal-poor (⟨[Fe/H]⟩=−1.57) and metal-rich (⟨[Fe/H]⟩=−0.61) groups show $V_0(TO)$=16.84±0.16 mag and 16.43 ±0.27 mag, respectively. Moreover, a quite significant dependence of $V(TO)$ on the projected galactocentric distance is observed: adopting a dividing line at $R_{gc} \sim 3.8$ kpc the innermost and outermost clusters of the whole sample show $V_0(TO)$=16.37±0.21 mag and 16.80±0.14 mag, while using only metal-poor clusters the peak magnitude is 16.32±0.21 mag (inner) and 17.02±0.22 mag (outer), with almost no difference in the mean metallicity of the two subsets. As a whole, such variations of the GCLF parameters with either R_{gc} or [Fe/H] appear at odds with the GGC behavior presented above, neither have been reported for other galaxies. As stated by BHB, a definitive answer on this issue will require better and less contaminated data on the M31 clusters and for this reason we prefer to use in the following discussion only the results concerning the full sample of metal-poor clusters.

Using $V_0(TO)$=16.84±0.16 mag together with the distance moduli given in Table 2, we derive the $M_V(TO)$ values listed in column (3) of Table 5. The comparison with the Galactic values listed in the previous Table 3 shows that the M31 absolute peak magnitudes are brighter by about 0.25 mag and 0.04 mag than the results based on the H96(a) and H96(b) sample, respectively. By accounting for the metallicity correction suggested by ACZ (see values in columns (4) and (5) of Table 5), the difference with the H96(a) results decreases to $\sim$ 0.16 mag, while that with the H96(b) ones is almost zero. On the other hand, we can keep away from any metallicity effect by directly comparing the metal-poor clusters in M31 with those in the Milky Way. From data in Table 4 and in column (3) of Table 5, one derives that the M31 peak magnitudes are 0.14 mag systematically brighter than the H96(a) ones, but almost coincident with those inferred from the H96(b) sample. To give a reason for these results, we note that the full sample in the BHB study is composed by clusters out of $R_{gc} \sim 1$ kpc from the center of M31 and that the median galactocentric distance of the metal-poor set is 5.5 kpc, in fair agreement with the constraints of Secker' selection which indeed was originally thought to simulate the Galaxy as if it were viewed from the outside and for this reason provides a better agreement with observations of GCs in external galaxies. However, it should be mentioned that the M31 distance moduli given in Table 2 refer to a field population of RR Lyrae stars and that the M31 GCs are expected at a variety of distances. In summary, no firm conclusion can be given, although we find evidence that the LFs of Galactic and M31 Globular Clusters suggest quite similar $M_V(TO)$ magnitudes, provided that the same $M_V(RR)$ calibration and internally consistent constraints to select the GC samples are adopted.

4 EXTERNAL GALAXIES

In their paper, ACZ show that the theoretical metallicity correction on the peak magnitude helps to remove the discrepancy between the GCLF and the Surface Brightness Fluctuations (SBF) distance scales. Following a different approach, we note that in the case of galaxies for which both types of methods are possible the GCLF universality can straightway be tested by considering the difference between $V(TO)$ and m^*, the SBF magnitude adjusted to a fiducial color (see later). Since the m^* absolute calibration is assumed to depend only on a zero-point, such a difference provides information for or against the constancy of the GCLF peak absolute magnitude, independently of the galaxy distance. With such a purpose, in the following we adopt the $V(TO)$ magnitudes measured by L01 by two-parameters fits to GCLFs in early-type galaxies together with the correspondent I-band SBF measurements by Tonry et al. (2001, hereafter T01) as adjusted to the fiducial color $(V-I)_0$=1.15 mag according to the T01 relation

$$m_I^* = m_I - 4.5[(V-I)_0 - 1.15] \qquad (7)$$

where $(V-I)_0$ is the galaxy color.

All the galaxies studied by L01 exhibit clear bimodal color distribution and for such a reason the peak magnitude was measured for either the blue and the red populations, as well as for the combined samples. These magnitudes are reported in Table 6 together with the mean metallicity of the combined, blue, and red samples, as determined using the L01 intrinsic $(V-I)_0$ colors and the relation of Kundu & Whitmore (1998), while Table 7 gives the T01 m_I^* values. As shown in the upper panel of Fig. 7, which deals with the combined samples and where open circles refer to measured

Table 6. Turnover magnitude and metallicity for GCLFs in Larsen et al. (2001) galaxies.

galaxy	$V(TO)_{all}$	[Fe/H]$_a$	$V(TO)_{blue}$	[Fe/H]$_b$	$V(TO)_{red}$	[Fe/H]$_r$
N0524	24.51 (0.09)	−0.79	24.34 (0.12)	−1.26	24.68 (0.14)	−0.28
N1023	23.53 (0.31)	−0.99	22.82 (0.47)	−1.59	23.92 (0.39)	−0.40
N3115	22.55 (0.21)	−1.06	22.45 (0.27)	−1.54	22.66 (0.33)	−0.45
N3379	22.78 (0.22)	−0.80	22.57 (0.30)	−1.34	23.02 (0.32)	−0.38
N3384	23.30 (0.12)	−0.88	22.98 (0.12)	−1.44	24.37 (0.30)	−0.19
N4365	24.37 (0.16)	−0.86	24.01 (0.14)	−1.26	24.83 (0.23)	−0.30
N4406	23.38 (0.11)	−0.91	23.28 (0.14)	−1.24	23.52 (0.17)	−0.49
N4472	23.78 (0.13)	−0.73	23.38 (0.15)	−1.44	24.21 (0.23)	−0.19
N4473	23.66 (0.12)	−0.96	23.46 (0.15)	−1.47	23.86 (0.15)	−0.43
N4486	23.50 (0.06)	−0.69	23.36 (0.10)	−1.40	23.58 (0.07)	−0.24
N4494	23.40 (0.11)	−1.24	23.24 (0.13)	−1.64	23.76 (0.22)	−0.69
N4552	23.32 (0.16)	−0.93	23.01 (0.21)	−1.39	23.61 (0.24)	−0.36
N4594	22.09 (0.10)	−0.73	21.80 (0.19)	−1.46	22.22 (0.12)	−0.30
N4649	23.58 (0.08)	−0.76	23.46 (0.13)	−1.39	23.66 (0.11)	−0.20

Table 7. SBF magnitudes and differences with the GCLF turnover magnitudes for Larsen et al. (2001) galaxies.

galaxy	m_i^*	$m_I^* - V(TO)_{all}$	$m_I^* - V(TO)_{blue}$	$m_I^* - V(TO)_{red}$
N0524	30.16 (0.20)	5.65 (0.22)	5.82 (0.23)	5.48 (0.24)
N1023	28.55 (0.15)	5.02 (0.34)	5.73 (0.49)	4.63 (0.42)
N3115	28.19 (0.08)	5.64 (0.22)	5.74 (0.28)	5.53 (0.34)
N3379	28.38 (0.10)	5.60 (0.24)	5.81 (0.32)	5.36 (0.33)
N3384	28.59 (0.13)	5.29 (0.18)	5.61 (0.18)	4.22 (0.33)
N4365	29.82 (0.16)	5.45 (0.23)	5.81 (0.21)	4.99 (0.28)
N4406	29.43 (0.13)	6.05 (0.17)	6.15 (0.19)	5.91 (0.21)
N4472	29.31 (0.09)	5.53 (0.16)	5.93 (0.17)	5.10 (0.25)
N4473	29.24 (0.12)	5.58 (0.17)	5.78 (0.19)	5.38 (0.19)
N4486	29.30 (0.15)	5.80 (0.16)	5.94 (0.18)	5.72 (0.17)
N4494	29.43 (0.09)	6.03 (0.14)	6.19 (0.16)	5.67 (0.24)
N4552	29.19 (0.13)	5.87 (0.21)	6.18 (0.25)	5.58 (0.27)
N4594	28.21 (0.17)	6.12 (0.20)	6.41 (0.26)	5.99 (0.21)
N4649	29.39 (0.14)	5.81 (0.16)	5.93 (0.19)	5.73 (0.18)
mean		5.67 (0.31)	5.93 (0.21)	5.38 (0.50)

peak magnitudes while filled ones depict the metallicity corrected values scaled to the average value [Fe/H]=−1.3 of all the GGCs (see Table 3), the difference between the two magnitudes is $m_I^* - V(TO)$=5.67±0.31 mag (no metallicity correction, dashed line) and 5.81±0.31 mag (metallicity corrected, solid line), thus suggesting for the GCLFs in these galaxies a reasonably similar absolute peak magnitude.

Moreover, by considering the blue clusters separately, we show in the lower panel in the same figure that the peak magnitudes scale even better with the SBF measurements yielding a difference $m_I^* - V(TO)$=5.93±0.21 mag (no metallicity correction, dashed line) and 5.99±0.22 mag (solid line) with a correction that accounts for the difference between the [Fe/H] values of the blue clusters (see data in column (5) of Table 6) and the average metallicity of the Galactic metal-poor clusters ([Fe/H]=−1.6, see Table 4). As for the red clusters, we find that the two magnitudes are poorly correlated for we derive $m_I^* - V(TO)$=5.38±0.50 mag (no metallicity correction) and 5.46±0.48 mag (metallicity corrected to the average metal content [Fe/H]=−0.6 of metal-rich GGCs (see Table 4)).

In summary, provided that the m_I^* absolute calibration is assumed to rest on a zero-point, the L01 data for galaxies showing a bimodal distribution in the GC colors suggest that the luminosity functions of the blue (metal-poor) clusters peak at the same absolute magnitude within ~ 0.2 mag, while for the GCLFs of the combined samples the constancy is attained within ~ 0.3 mag as a result of the quite scattered peak magnitudes of the red (metal-rich) globular clusters. This behavior holds even if the ACZ theoretical metallicity correction is taken into account, likely suggesting that in external galaxies the metal-rich GCs may have different ages and/or mass distributions than the metal-poor component. Apparently, this result disagrees with Kundu & Whitmore (2001a,b) whose sample contains few galaxies which show evidence of bi-modality in the GC color distribution, but for which they find agreement between the GCLF and the SBF distances considering the metal content and peak magnitude of the GC full samples. However, by inspection of Table 6 of Kundu & Whitmore (2001a) we note that the dif-

Table 8. SBF calibration from Cepheid distances.

galaxy	[O/H]	m_I^*	$\mu_0(\mathrm{KP}_n)$	$\mu_0(\mathrm{KP}_{n,Z})$	μ_0(F02)
LMC	−0.40		18.50	18.50	18.50
N7331	−0.23	28.86 (0.14)	30.81 (0.09)	30.84 (0.09)	30.71 (0.09)
N3031	−0.15	26.21 (0.25)	27.75 (0.08)	27.80 (0.08)	27.63 (0.09)
N4258	−0.05	27.57 (0.08)	29.44 (0.07)	29.51 (0.07)	29.32 (0.06)
N4725	+0.02	28.87 (0.32)	30.38 (0.06)	30.46 (0.06)	30.28 (0.07)
N0224	+0.08	22.67 (0.05)	24.38 (0.05)	24.48 (0.05)	24.30 (0.08)
N3368	+0.30	28.34 (0.20)	29.97 (0.06)	30.11 (0.06)	30.09 (0.10)
N4548	+0.44	29.68 (0.53)	30.88 (0.05)	31.05 (0.05)	31.20 (0.05)
galaxy			M_I^*	M_I^*	M_I
N7331			−1.96 (0.17)	−1.99 (0.17)	−1.86 (0.17)
N3031			−1.54 (0.26)	−1.59 (0.26)	−1.42 (0.26)
N4258			−1.87 (0.11)	−1.94 (0.11)	−1.75 (0.10)
N4725			−1.51 (0.33)	−1.59 (0.33)	−1.40 (0.33)
N0224			−1.71 (0.07)	−1.81 (0.07)	−1.64 (0.09)
N3368			−1.63 (0.21)	−1.77 (0.21)	−1.75 (0.22)
N4548			−1.20 (0.53)	−1.37 (0.53)	−1.52 (0.53)
median			−1.63 (0.05)	−1.77 (0.05)	−1.64 (0.05)
w-mean			−1.75 (0.05)	−1.84 (0.05)	−1.68 (0.05)

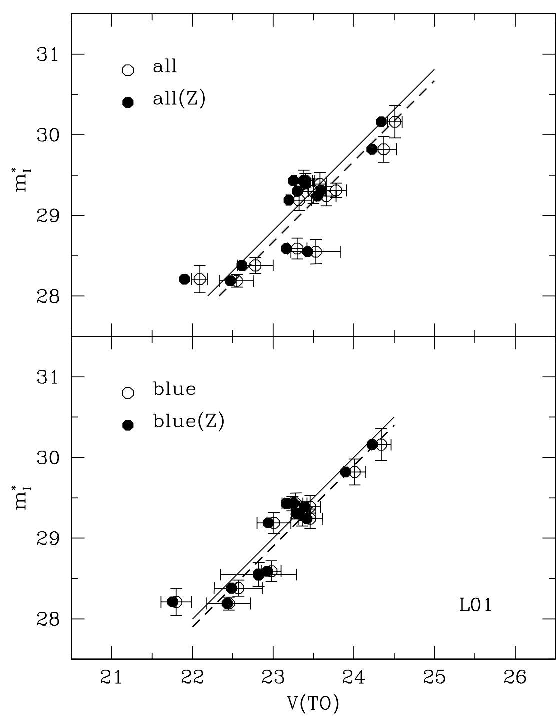

Figure 7. SBF measurements versus GCLF peak magnitudes for the external galaxies studied by Larsen et al. (2001). The upper panel refers to the combined samples of GCs, while the lower one deals with blue (metal-poor) clusters. Open and filled circles depict observed and metallicity corrected peak magnitudes, respectively (see text).

ference $\Delta\mu_0$(GCLF-SBF[2]) varies from −0.27 to +0.67 mag, while from Table 3 in Kundu & Whitmore (2001b) one has that the difference between the GCLF distance moduli and those from the literature ranges from −0.70 to +0.38 mag, depending on the galaxy.

We stress again that all the above discussion relies on the assumption that the absolute calibration of the SBF m_I^* magnitudes depends only on a zero-point. In this case, the differences $m_I^* - V(TO)_{blue}$ given in Table 7 would yield that the absolute peak magnitudes for the metal-poor clusters in the L01 galaxies have a scatter of about 0.2-0.3 mag, which means 2-3 Mpc at Virgo distances. As a matter of the fact, looking at the M_I^* magnitudes given by Tonry et al. (1999) for six calibrating galaxies (see their Table 2) one finds a range of $\sim$ 0.5 mag, with even the best SBF measurements giving $M_I^* = -1.77 \pm 0.12$ (NGC224) and -2.04 ± 0.19 mag (NGC7331). On this ground, it is quite difficult to distinguish whether the scatter in the $m_I^* - V(TO)_{blue}$ differences reflects a real scatter of the absolute peak magnitudes or is due to the intrinsic uncertainty of the SBF calibration.

Concerning the latter point, Tonry et al. (1999), using the Ferrarese et al. (2000) HST Cepheid distances to the six calibrating galaxies, prefer to adopt the median value M_I^* = −1.74±0.08 mag rather than the weighted mean −1.80±0.08 mag, given the wide range in the errors in the SBF measurement. Accordingly, for all the blue clusters in the L01 galaxies we derive $M_V(TO)$=−7.67±0.23 mag and −7.73±0.23 mag, depending on whether the ACZ metallicity correction is neglected or used, respectively, *within a Cepheid distance scale calibrated on μ_0(LMC)=18.50 mag.*

This is a crucial point to be considered before comparing these peak absolute magnitudes with those of metal-poor clusters in the Milky Way since the values listed in Table 4 are correlated to the LMC distance moduli given in Table 2 for the various $M_V(RR)$-[Fe/H] relations. In other words, if we adopt μ_0(LMC)=18.50 mag, then the peak absolute magnitude of Galactic metal-poor clusters is $M_V(TO)$=−7.50±0.10 mag and −7.66±0.11 mag for the H96(a) and H96(b) samples, respectively. On this basis, as already presented for the metal-poor GCs in M31, we find a

[2] SBF data from Neilsen 1999

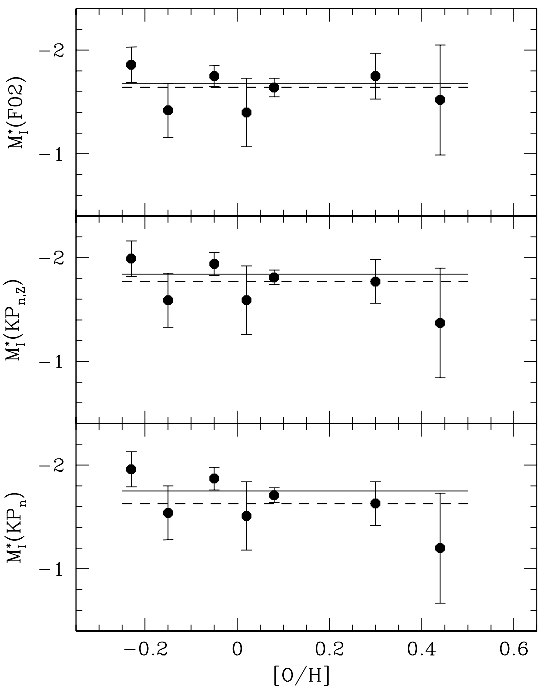

Figure 8. SBF absolute magnitudes of calibrating galaxies as a function of the galaxy oxygen abundance. The three panels deal with the revised Cepheid distances by Freedman et al. (2001) without metallicity correction (KP$_n$) and adopting either the empirical correction (KP$_{n,Z}$) or the theoretical one (F02). Dashed and solid lines show the median value and the weighted mean, respectively.

better agreement with the Galactic peak magnitude dealing with the Secker's selection of GCs.

However, as discussed in Jensen et al. (2003), the zero-point of the SBF calibration follows the uncertainties of the Cepheid scale: indeed, we show in Table 8 that the revised HST Cepheid distances determined by Freedman et al. (2001, KP$_n$) for the SBF calibrating galaxies[3] would lead to the slightly fainter median value $M^*_I = -1.63 \pm 0.05$ mag and weighted mean -1.75 ± 0.05 mag. Furthermore, one should also consider the occurrence of a metallicity effect on the Cepheid distance scale. Using the empirical relation adopted by Freedman et al. (2001), namely $\Delta\mu_0 = -0.2\Delta$[O/H] where Δ[O/H] is the difference between the oxygen abundance of the galaxy and that of LMC, the metallicity corrected distance moduli (KP$_{n,Z}$) yield a median value and a weighted mean as $M^*_I = -1.77 \pm 0.05$ mag and -1.84 ± 0.05 mag, respectively.

In several papers, the occurrence of a metallicity effect on the Cepheid distance scale is rejected also in consideration of a mistakenly believed disagreement between the empirical correction adopted by Freedman et al. (2001) and the predicted one $\Delta\mu_0$=+0.27$\Delta\log Z$, as based on nonlinear convective models of Cepheid structures (see Caputo, Marconi & Musella 2002 and references therein) with Z in the range of 0.004 (Small Magellanic Cloud) to 0.02 (roughly solar chemical composition). As a matter of fact, it should firstly be clear that the empirical correction holds with the oxygen abundance of the parent galaxy, whereas the theoretical one is based on the chemical composition of the Cepheids. Moreover, it has been shown (Fiorentino et al. 2002, F02) that the theoretical correction is not linear over the whole metallicity range covered by galaxies hosting Cepheids, with a turnover at about solar chemical composition and with sign and amount of the correction depending on both the helium and metal content of the Cepheid. On this basis, F02 showed that the empirical metallicity correction suggested by Cepheid observations in two fields of the galaxy M101 may be accounted for adopting a helium-to-metal enrichment ratio $\Delta Y/\Delta Z \sim 3.5$, as also confirmed on the basis of an updated extended model set (Marconi, Musella & Fiorentino 2005). It is also of interest to note that recent high-resolution spectroscopic abundances for Galactic and Magellanic Cloud Cepheids (Romaniello et al. 2005) show that the Cepheid luminosities are incompatible with the empirical linear correction, whereas are fairly described by the F02 non-monotonic theoretical behavior with a helium-to-metal enrichment ratio $\Delta Y/\Delta Z$=2.5-3.5. As for the effects on the SBF calibration, we show in Fig. 8 the absolute M^*_I values of the calibrating galaxies as a function of the [O/H] abundance of the galaxies (see also Table 8). The three panels refer to the HST revised distance moduli by Freedman et al. (2001) without metallicity correction (KP$_n$) and using both the empirical (KP$_{n,Z}$) and the theoretical correction (F02) with $\Delta Y/\Delta Z$=3.5. With reference to the median values (dashed line) and the weighted means (solid line), one has that a metallicity correction to the measured Cepheid distances is *needed* to remove the trend of M^*_I with the oxygen abundance, and that the theoretical relation seems to work better than the empirical one to give a fairly constant SBF zero-point.

Eventually, we note that using the weighted mean M^*_I=-1.68 ± 0.05 mag provided by the theoretically corrected distance moduli to the SBF calibrating galaxies together with the ACZ metallicity correction yields that the peak absolute magnitude of the L01 blue GCs is $M_V(TO) = -7.67 \pm 0.23$ mag which is astonishingly coincident with the values -7.66 ± 0.11 mag and -7.65 ± 0.19 mag inferred by metal-poor clusters in the Milky Way and M31, respectively, *at* μ_0*(LMC)=18.50 mag.* In closure, we wish to mention that a recent theoretical SBF calibration (Cantiello et al. 2003) yields M^*_I=-1.74 ± 0.23 mag, as determined using stellar evolutionary tracks computed with the same input physics adopted for our pulsation models of RR Lyrae and Cepheid structures, in particular for those computed by B03 and F02. On these grounds, we should adopt μ_0(LMC)=18.53 mag and the weighted mean provided by the SBF calibrating galaxies becomes M^*_I=-1.71 ± 0.05 mag, that is practically coincident with the theoretical value, with the above $M_V(TO)$ luminosities increased by 0.03 mag.

5 CONCLUSIONS

In this paper, we have investigated the universality of the GCLF and the use of the peak magnitude for reliable dis-

[3] For N224 (M31) ground observations by Freedman & Madore (1990) were used.

tance determinations to external galaxies. The main results may be summarized as follows:

(i) Concerning the dependence of the Milky Way GCLF on the adopted M_V-[Fe/H] relation to get the cluster distances, we find no significant effects on the absolute peak magnitude $M_V(TO)$, with the exception of the one based on the revised Baade-Wesselink method (F98), that provides a fainter magnitude by about 0.15 mag. Moreover, we show that the selection of the GC sample may influence the peak magnitude: in particular, for each given $M_V(RR)$-[Fe/H] relation, using only GCs with reddenings $E(B-V) \leq 1.0$ mag and Galactocentric distances $2 \leq R_{GC} \leq 35$ kpc, as earlier suggested by Secker (1992) to treat the Galaxy as if it were viewed from the outside, yields that the peak magnitude becomes systematically brighter by about 0.2 mag. As a whole, the combined effects of the adopted $M_V(RR)$ calibration and selective criteria are the main reason for the discordant Galactic peak magnitudes presented in the relevant literature.

(ii) Grouping the Galactic clusters by metallicity, the peak magnitude of the metal-poor ([Fe/H]< -1.0] subsample is brighter than that of the metal-rich ([Fe/H]> -1.0] one by about 0.36 mag. This empirical results meets, also in a quantitative way, the theoretical metallicity effects suggested by Ashman, Conti & Zepf (1995) on the basis of synthetic GC populations with similar age and mass-function. As for the dependence on the Galactocentric distance, we found that the shape of the GCLF is broader for the outer halo ($R_{GC} > 8$ kpc) than for the inner one, but with no significant effect on the peak luminosity.

(iii) Using BHB data for metal-poor GCs in M31, we find a close agreement with the metal-poor Galactic sample results, as obtained according to the Secker's selection and using the same $M_V(RR)$ calibration to get cluster distances.

(iv) Concerning external galaxies with available deep photometry and close enough to have apparent GCLF extending below the turnover, we use the sample provided by Larsen et al. (2001) which contains galaxies showing a bimodal distribution of the GC color (and consequently of the metallicity). Given the absence of RR Lyrae stars to measure the galaxy distances, we use the I-band SBF measurements (Tonry et al. 2001) to evaluate the difference between the apparent peak magnitude $V(TO)$ and the SBF magnitude m_I^*, as adjusted to the fiducial color $(V-I)_0 = 1.15$ mag. In this way, we show that the blue (metal-poor) cluster component peaks at the same luminosity within $\sim$ 0.2 mag, while the GCLFs of the full samples show constant values within $\sim$ 0.3 mag as a consequence of the quite scattered peak magnitudes of the red globular clusters. The adoption of the theoretical metallicity correction by ACZ does not significantly modify these results, thus suggesting that in external galaxies blue and red globular clusters may have different ages and/or mass distributions.

(v) Following the universally accepted assumption that the absolute calibration of the SBF m_I^* magnitude depends only on a zero-point, we analyze the Cepheid distances to the calibrating galaxies, as determined by Freedman et al. (2001) within a Cepheid distance scale calibrated on $\mu_0(LMC) = 18.50$ mag. We firstly show that the SBF absolute magnitude M_I^* of the calibrating galaxies becomes brighter with decreasing the galaxy oxygen abundance, suggesting the occurrence of a metallicity effect on the Cepheid distance scale. Once the Cepheid distances are corrected using either the empirical (Freedman et al. 2001) or the theoretical (Fiorentino et al. 2002) metallicity corrections, the trend is reduced. In particular, we find that the peak absolute magnitude of the extragalactic metal-poor clusters is practically identical to the Milky Way and M31 values, provided that the Secker's selection of Galactic clusters and the theoretical metallicity corrections on both the GCLF peak magnitude and the Cepheid distance are adopted.

(vi) Finally, *within a Cepheid and RR Lyrae distance scale calibrated on μ_0(LMC)=18.50 mag*, the three sets of metal-poor GCs give $M_V(TO)=-7.66\pm0.11$ mag (Milky Way), -7.65 ± 0.19 mag (M31), and -7.67 ± 0.23 mag (extragalactic clusters). This would suggest a value of -7.66 ± 0.09 mag (weighted mean), with any modification of the LMC distance modulus producing a similar variation of the GCLF peak luminosity.

ACKNOWLEDGMENTS

Financial support for this study was provided by MIUR under the PRIN project "Continuity and Discontinuity in the Milky Way Formation" (P.I. Raffaele Gratton) and by Regione Campania under the scientific project "Fundamental Astronomy: refining the steps of the distance ladder" (P.I. Marcella Marconi). It is a pleasure to thank G. Bono, V. Castellani, E. Iodice, S. Larsen and B. Madore for several comments, and E. Brocato and G. Raimondo for discussions on the SBF method.

REFERENCES

Ashman, K., Conti, A., Zepf, S., 1995, AJ, 110, 1164 (ACZ)
Barmby, P., Huchra, J., Brodie, J., 2001, AJ, 121, 1482 (BHB)
Benedict, G. et al., 2002, AJ, 123, 473
Bono, G., Caputo, F., Castellani, V., Marconi, M., Storm, J., Degl'Innocenti, S., 2003, MNRAS., 344, 1097 (B03)
Borissova, J., Minniti, D., Rejkuba, M., Alves, D., Cook, H., Freeman, K., 2004, A&A, 423, 97
Brown, T., Ferguson, H., Smith, E., Kimble, R., Sweigart, A., Renzini, A., Rich, R.,2004, AJ, 127, 2738
Cacciari, C., Clementini, G., 2003, LNP, 635, 105
Cantiello, M., Raimondo, G., Brocato, E., Capaccioli, M., 2003, AJ, 125, 2783
Caputo, F., Castellani, V., Marconi, M., Ripepi, V., 2000, MNRAS, 316, 819
Caputo, F., Marconi, M., Musella, I., Santolamazza, P., 2000, A&A, 359, 1059
Caputo, F., Marconi, M., Musella, I., 2002, ApJ, 566, 833
Carretta, E., & Gratton, R., 1997, A&AS, 121, 95
Cassisi, S., Castellani, M., Caputo,F., Castellani, V., 2004, A&A, 426 ,641
Clementini, G., Gratton, R., Bragaglia, A., Carretta, E., Di Fabrizio, L., Maio, M., 2003, AJ, 125,1309
Dall'Ora, M. et al., 2004, ApJ, 610, 269
Della Valle, M., Kissler-Patig, M., Danziger, J., Storm, J., 1998, MNRAS, 299, 267
Demarque, P., Zinn, R., Lee, Y., Yi, S, 2000, AJ, 119,1398
Di Criscienzo, M., Marconi, M., Caputo, F.,2004, ApJ, 612, 1092
Fernley, J., Skillen, I., Carney, B. W., Cacciari, C., Janes, K., 1998, MNRAS, 293, 61 (F98)
Ferrarese, L., Ford, H., Huchra, J., et al, 2000, ApJS, 128, 431

Fiorentino, G., Caputo, F.,Marconi, M., Musella, I., 2002, ApJ, 76, 402 (F02)
Fitzpatrick, E. L., Ribas, I., Guinan, E. F., Maloney, F. P., Claret, A., 2003, ApJ, 587, 685
Freedman, W., Madore, B., 1990, AJ, 335, L35
Freedman, W. et al., 2001, ApJ, 553, 47
Gibson, B.K., 2000, MmSAI, Vol. 71, p. 693
Gratton, R., Bragaglia, A., Carretta, E., Clementini, G., Desidera, S., Grundahl, F., Lucatello, S., 2003, A&A, 408, 529
Harris, W., 2001, stcl.conf., 223
Harris, W., 1996, AJ, 112 (update 2003 avaible on http://physun.physics.mcmaster.ca)
Inman, R. & Carney, B., 1987, AJ, 93,1166
Jensen, J., Tonry, J., Barris, B., Thompson, R., Liu, M., Rieke, M., Ajhar, E., Blakeslee, J., 2003, ApJ, 583, 712
Kavelaars, J. J., Hanes, D. A., 1997, MNRAS, 285, 31
Kraft, R. & Evans, I.,2003, PASP, 115, 143
Kundu, A., Whitmore, B., 1998, AJ, 116, 2841
Kundu, A., Whitmore, B., 2001a, AJ, 121, 2950
Kundu, A., Whitmore, B., 2001b, AJ, 122, 1251
Larsen, S., Forbes, D., Brodie, J., Huchra, J.,Forbes, D., Grillmair, C., 2001, AJ, 121, 2974 (L01)
Lee, M., Kim, E., 2000, AJ, 120, 260L
Lee, M., Kim, E., Geisler, D., 1998, AJ, 115, 947L
Marconi, M., Musella, I., Fiorentino, G., 2005, ApJ, submitted
Neilsen, E., 1999, PhD thesis
Panagia, N.,1998, MmSAI, 69, 225
Puzia, T., Kissler-Patig, M., Brodie, J., Huchra, J., 1999, AJ, 118, 2734
Richtler, T., 2003, LNP, 635, 281
Romaniello, M., Primas, F., Mottini, M., Groenewegen, M., Bono, G., Franois, P, 2005, A & A, 429, 37
Sandage A., 1993, AJ, 316, 719 (S03)
Sandage, A., Tammann, G., 1995, ApJ, 415
Secker, J., 1992, AJ, 104, 1472
Secker, J., Harris, W., 1993, AJ, 105, 135
Tonry, J., Dressler, A., Blakeslee, J., Ajhar, E., Fletcher, A., Luppino, G., Metzger, M., Moore, C., 2001., ApJ, 546, 681
Tonry, J., Ajhar, E., Blakeslee, J., Dressler, A., 1999, A&AS, 194
Walker, A., 1992, ApJ, 390, 81
Whitmore, B., Sparks, W., Lucas, R., Macchetto, F., Biretta, J., 1995, ApJ, 454, 73
Zinn, R. & West, M., 1984, ApJS, 55,45
van den Bergh, S., 2003, ApJ, 590
van den Bergh, S., Mackey, A., 2004, MNRAS, 354